Designing Effective Web-Based Learning Environments Using the Keller Plan and Media-Friendly Tools

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Abstract

This paper summarizes the authors' efforts to create effective learning environments suitable for the new millennium. The University of Missouri Rolla (UMR) Engineering Management Department is currently responding to the challenge to deliver a Masters of Engineering Management degree program statewide. To facilitate this, a virtual campus must be created for students that may be place-bound at essentially any location in Missouri. In addition, recent contracts with The Boeing Company require the delivery of a new degree in Systems Engineering to Boeing sites worldwide and noncredit courses in Saudi Arabia. This paper discusses the authors' thinking on and latest efforts to create effective learning environments using modern technology.

1. Introduction

The Engineering Management Department at the University of Missouri has been charged with the responsibility of delivering a Masters level degree program to students anywhere in the state of Missouri. The department has a very strong tradition of service to the state, nation and the world through distance education efforts of various kinds over the past thirty years, and has been a major provider of courseware to NTU (National Technological University), with several department faculty honored for outstanding teaching. Professor Ragsdell has been involved in distance education (as a professor and administrator) since 1973 (Purdue), and has delivered courses in every conceivable format across the US and around the world. In addition, the Engineering Management department has regularly delivered on-site courses and entire MS degree programs for industry (in Missouri and around the world), and has participated aggressively in the University of Missouri Video Network (UMVN), and has been an active participant in the course offerings of the UMR Graduate Engineering Education Center in St. Louis, since its beginning in the 1960's.

These outreach efforts have been accomplished with a variety of delivery formats; including live on-site (professor commutes), tape-delayed presentation, two-way video/two-way audio with a live on-campus class, and web-based with streaming audio and/or video. These delivery formats have relative strengths and weaknesses from the viewpoint of students, faculty and administrators. None of the delivery formats used to date seems to be perfect from all perspectives. Distance students are often employed part or full time, and have significant time constraints due to job-related assignments and travel and family requirements.

The Internet provides a convenient channel of communication to place-bound students. To fully exploit the capabilities of this medium, the efficacy of the Personalized System of Instruction (Keller Plan) is being investigated through the development and implementation of various learning environments. Observations are discussed relative to delivery format in light of student learning style and faculty workload, as well as observations related to the design of six courses being prepared for Internet delivery. The six courses are introductory courses in statics and dynamics (Basic Engineering 50 and Basic Engineering 150); a dual level course on Total Quality Management (EMgt-375); a dual level Introduction to Quality Engineering (EMgt-376); a doctoral level course on Quality Engineering (EMgt-475); and a dual level course on Engineering Design Optimization (EMgt-374). This is a work in progress; therefore, findings to date will be discussed with an emphasis on those efforts that seem to work. Experience with a variety of software development and delivery tools including ToolBook, Dreamweaver, PowerPoint, Flash, RealSystems, and other video and audio formats are discussed. The value of simulation and on-line testing is discussed in light of student learning style and a self-paced learning environment based on the Keller Plan.

2. The Keller Plan (Personalized System of Instruction)

F. S. Keller[1] began to implement his ideas for a new way of teaching in the early 1960's at Columbia University and later at the University of Sao Paulo in Brazil. His thoughts were influenced by the work of B. F. Skinner at Harvard and Charles Ferster at the Institute for Behavioral Research in Maryland. Generally, they ask the same question that besets us today – "Why do my students refuse to learn?" Keller devised a plan (with help from his many students and collaborators), which was designed to maximize learning by stressing achievement and positive reinforcement. This approach has come to be called The Keller Plan, Self-Paced Instruction, or the Personalized System of Instruction. The key elements of the system are:

- Clear educational objectives
- Small learning modules with associated achievement tests and immediate feedback
- Student self-pacing
- Positive reinforcement
- Student emphasis on doing rather than listening

Keller's approach accommodates a variety of learning styles, and seems to be a natural for today's college students, since it encourages asynchronous learning. The Instructional Software Development Center (ISDC), directed by Professor Davis at the University of Missouri-Rolla, has used Keller's approach in varying degrees in a number of courses currently under development. Student feedback suggests that they very much enjoy the opportunity to proceed at their own pace. The Keller Plan appears to be a natural way of implementing web-based courses for place-bound distance students and on-campus students.

3. Statics On-Line

Statics On-Line has become an integral part of the undergraduate engineering statics class (Basic Engineering 50) at UMR. This program provides a number of mini lectures, with audio and graphics, some self-assessment tests, example problems, and a number of on-line homework problems that are generated individually for each student and graded by the computer. Students are given two attempts at each homework problem without a penalty. They may earn one-half credit for correct answers submitted up to five days after the deadline. The students' grades for these homework problems are returned to the student and posted in the instructor's grade book. The coordinated use of audio, text, and graphics is illustrated in Figure 1, which shows a typical mini lecture in Statics On-Line. Text and graphics are presented in the large central frame, audio controls are located in the lower left frame, and navigation controls are located in the top and lower right frames. Interested readers may access the program at http://www.umr.edu/~oci. To try the program from the student's viewpoint, use 000001 for the student number and 0001 for the student access number. This will allow the reader to have a homework problem assigned and graded. The University of Missouri-Rolla used the Statics On-Line program very successfully during the 1998-99 academic year with approximately 250 local students plus a remote class in Kansas City.

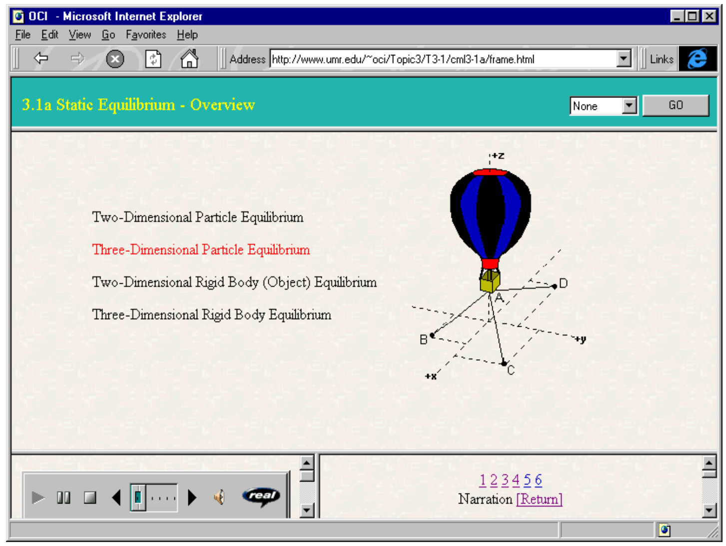

Figure 1: Statics On-line Lesson

4. BEST Dynamics

Engineering Dynamics is the study of motion, but textbooks and chalkboards, the traditional classroom teaching tools, cannot conveniently show this motion. Mechanical models are helpful, but relatively inflexible; they are qualitative, not quantitative. The ISDC at UMR has been developing and classroom testing the BEST Dynamics program with the goal of improving the teaching and learning of engineering dynamics. Figure 2 illustrates a typical example problem in which the student is methodically guided through the solution process. Example problems are followed by simulations, which allow the student to vary key problem parameters, then watch a dynamic simulation of the problem. About forty-five different problem simulations, representing a selection of typical kinetics and kinematics problems for both particles and rigid bodies, have been completed and incorporated in the computer-based training program. These simulations enable the user to vary inputs, and to view a wide variety of configurations and behavior. Solution sections, which give detailed support in writing and solving equations, have been included with each class/category of problems. BEST Dynamics is currently used to augment the classroom lectures in the undergraduate dynamics class (Basic Engineering 150) at UMR.

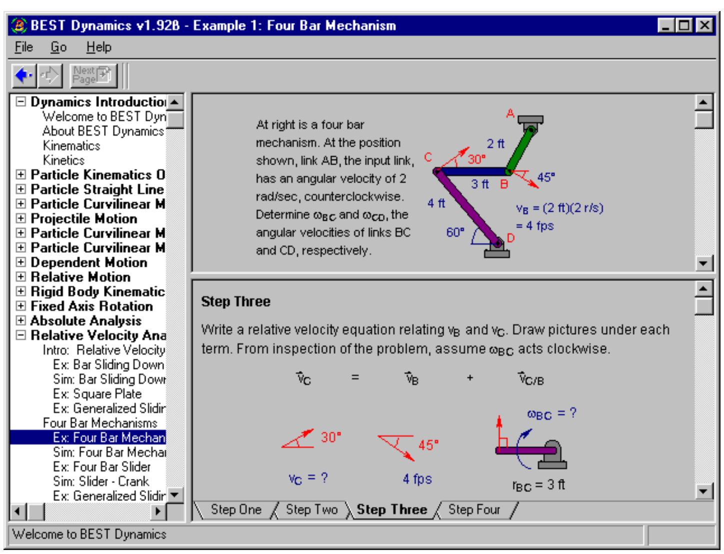

Figure 2: Example Problem in BEST Dynamics

5. Quality Engineering (Engineering Management 376 and Engineering Management 475)

During the spring semester of 1999 a graduate level course entitled Quality Engineering, covering the Taguchi System of Quality Engineering and related topics, was given to 18 on-campus students and 22 off-campus students. The off-campus students included officers in the Army who were in training at Fort Leonard Wood, full time employees at 3M in Columbia, TEVA (a pharmaceutical company in Mexico), a University of Missouri-Columbia student and full time employees at Boeing in St. Louis. An added complication was that the Army students were in an accelerated program, which required that they take semester courses in 8 weeks. Accordingly, the Army students joined the course at the halfway point and finished with the others. Clearly, it would be impossible to travel to each of the locations where enrolled students resided. The class had previously been taught via two-way audio and two-way video to students at McDonnell Douglas (now Boeing) in St. Louis. Channel capacity would not allow this approach, so alternatives were considered. In the end the course was offered to the on-campus students live, but in the video communication center; and copies of the recorded lecture/discussion periods were mailed to the remote sites. Feedback from prospective students prior to the first class made it clear that this would not be sufficient, so other avenues of communication were sought that would accommodate the off-campus students' need to fully participate in the course of study. All of the remote sights were visited during the semester, and several visits were made to the 3M site in Columbia. In addition, most remote students visited Rolla at least once during the term. Off-campus student feedback indicated that this was NOT enough. It is important to note that off-campus students tend to require more personal attention than on-campus students do.

5.1 Course Augmentation through the World Wide Web

A course homepage was created to mitigate some of the problems noted above. Interested readers can visit the web page at http://www.umr.edu/~design and select EMgt-475 as shown in Figure 3. This homepage was designed to serve as a convenient source of information transfer, and to provide an additional avenue of communication through a chatroom and email.

All of the PowerPoint slides used in the lectures are available on the course homepage, and can be viewed on the Internet or downloaded and viewed and/or printed. The slides include animations and other effects intended to maintain student interest. Since all lectures were videotaped, copies were placed in the library so that on-campus students could review lecture topics after class, as their schedules allowed. Of course, all off-campus students have access to the taped lectures, which are viewed as a class and later on-demand,

Figure 3: Quality Engineering Web Site

individually and in groups. In the future, these and other useful videos will be available directly to students on the Internet in streaming format.

The homepage includes easy access to all handouts. In fact, handout material is no longer copied and distributed in class. A simple announcement is made in class of the availability of the material on the web. The material is scanned and placed on the web and is printed by the students using Acrobat Reader[2]. In this way the material can be viewed either full size, or in expanded format if content dictates. Relevant publications by Professor Ragsdell and others are also included. Copies of tests from previous semesters are included for the benefit of the students, as well as a spreadsheet containing grades to date. A chat room is provided to the students so that frequently-asked questions can be viewed by the class, regardless of their location. A time was selected which was convenient for most students, when Professor Ragsdell would be on-line in the chatroom. Perhaps not surprisingly, students asked questions via the chatroom and email that they would not ask in class.

5.2 Guest Lecturers

Expert guest lecturers visited Rolla and gave case study lectures during the regular class time, which were videotaped and made available to students in the normal fashion. During the spring semester of 1999, Shin Taguchi (American Supplier Institute), Larry Smith (Ford Motor Company), and Jim Coté (General Motors) contributed to the course as guest lecturers. In addition, Dr. Creveling (co-author of the text currently used) provided solutions to exercises which were, in turn, provided to EMgt-475 and EMgt-376 students via the course web page. Outside speakers are extremely popular with the students, and through videotapes of their lectures, they have made a significant and ongoing contribution to the course. Additional guest lectures will be added in future semesters, thereby creating a library of case studies given by the actual contributors. This is clearly superior to a discussion of the case study by even the most gifted professor.

5.3 Semester Project

Years of teaching this course and the encouragement of Dr. Genichi Taguchi suggested the need to include a semester project as a pivotal part of this course. All students are encouraged to propose an appropriate project early in the course. Students, both on-campus and off-campus, are encouraged to form teams in order to define and execute the project. Off-campus students are encouraged to select a project closely related to their work assignment. Students or student teams that fail to propose a suitable project in the allotted time are assigned a project. Usually this assigned project is used throughout the semester as a discussion vehicle to demonstrate the principles covered in the course. Project reports from past semesters are available on the course homepage. A major portion of the student's grades is associated with the project and the required written and oral reports. Some students fail to see the value of the project at first, but attitudes change rapidly as they make progress with the project. Many students report after the course that the project was the most significant learning experience of the course. Clearly, the project is an essential element of this course. Professors seem to believe that the profound content of their lectures coupled with their eloquent delivery offers the greatest opportunity for learning in any course. Students seem to disagree, and prefer to learn by doing rather than by listening!

5.4 Simulations

The textbook[3] currently used in the course (Fowlkes and Creveling, 1995) includes several simple case studies, which clearly demonstrate the major points covered in the book and the course. One of these, the catapult, has been simulated using the ToolBook authoring system as shown in Figure 4. This and other simulations are used in class and by the students at their convenience on the web as tools to encourage experimentation and application of the statistical and design methods covered in the course. Students use the simulation to gather and perform planned experiments using appropriate orthogonal arrays for control and noise factors. In this way data is collected accurately and more conveniently. Students use a spreadsheet package to organize the experimentation and check selected results posted on the web. These simulations stimulate student interest and invigorate class discussion.

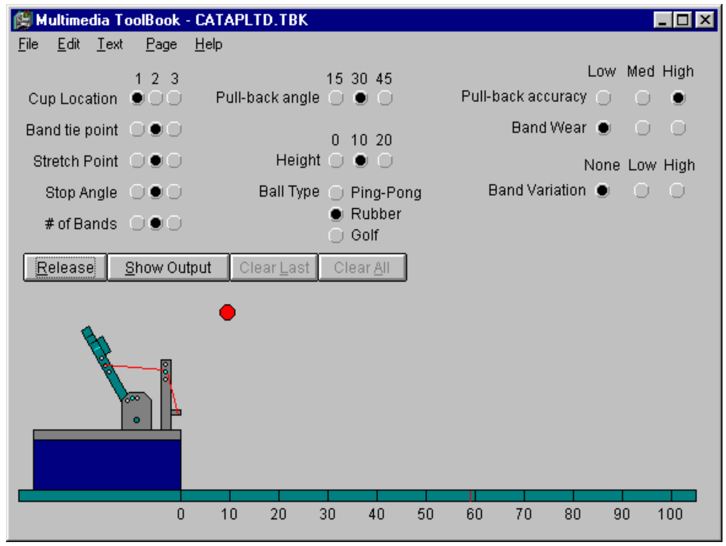

Figure 4: Catapult Simulation

5.5 Web-Deployed, Self-Paced Instruction

A fully web-deployed version of this course is currently in development, which employs the key features of Keller's Personalized System of Instruction. An early version of this web site is shown in Figure 5. This resource offers all of the capabilities of the original course homepage, but also incorporates audio, video, and dynamic textual content, thereby replacing the lecture portion of the course and eliminating the need to distribute videotaped lessons to the off-campus students. Course content is arranged in appropriately sized learning modules, each containing exercises to assess the student's progress. Research is underway intended to lead to the development of an adaptive interface and navigation logic, which will adjust to student learning style and pace. Chat capability provides the key means of fostering teamwork and collaboration. WebCT[4] is

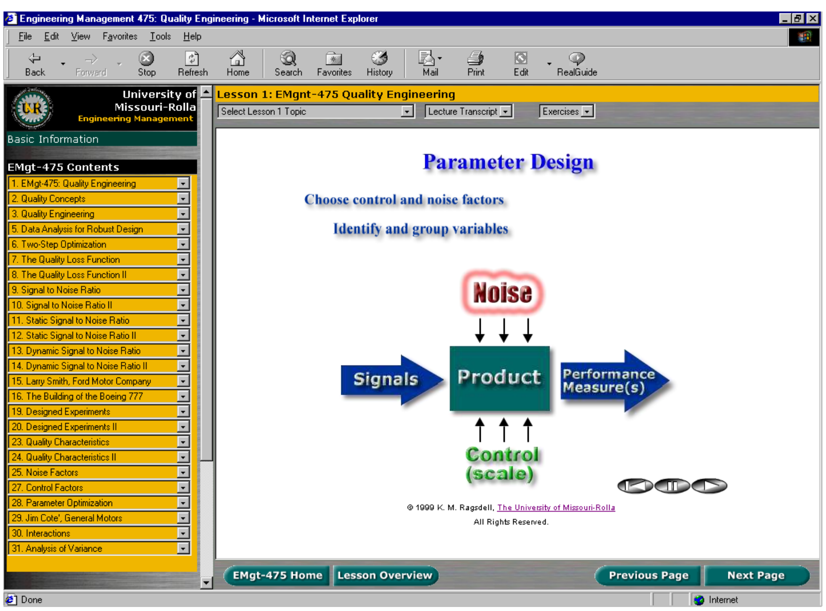

Figure 5: Quality Engineering 2000
Self Paced Website

used for course management and to automate pre-module and post-module testing, grade keeping and reporting; and provides chatroom capability. Students are placed in learning teams so that they can assist each other with course material and to work in a simulated team environment (regardless of location) on the assigned semester project. One chatroom is reserved for discussion with all class members. Professor Ragsdell joins the chatrooms as required. As before, all of the course materials are available for review or printing in either text or Acrobat formats. When complete, this tool should provide a highly-effective means of delivering the entire Quality Engineering course to place-bound students using little more than a mainstream Pentium-class or Macintosh computer connected to the Internet.

6. Total Quality Management (Engineering Management 375)

Professor Ragsdell has developed and taught a course entitled Total Quality Management since 1989 at UMR. This course is based on twenty plus years of interaction with industrial leaders in the US and Japan, such as General Motors, Ford, Xerox, Nissan, Nippon Denso, and government leaders in Missouri, the US and Asia. The course has been given using every conceivable format. In Fall, 1999 the course was reorganized to a two lecture/one lab period per week format. A web page which contains all handout material (course schedule, lab assignments, publications, etc.), lecture slides, and grade book was created for the course. Interested readers can visit the web page at http://www.umr.edu/~design by selecting EMgt-375. Total Quality Management, as presented here and increasingly understood throughout the world, is a philosophy, associated methods and tools, and actions which compel an entire organization, from the lowest to highest level, to excellence and efficiency in personal and corporate activities. Many have contributed to the development of Total Quality Management (TQM), but the most important contribution seems to be the work of Deming[5,6,7,8,9]. The authors do not wish to diminish the contribution of others, but the UMR presentation of Total Quality Management is essentially the Deming Way, and follows closely the approach used by Ragsdell in his industrial and government short courses, as well as in his course at UMR entitled EMgt-375: Total Quality Management.

6.1 BEST TQM

The laboratory portion of EMgt-375 is supported by a multimedia learning environment called BEST TQM. This is a self-contained, information intensive and stimulating learning environment containing many topics covered in the course. BEST TQM is not designed to be a stand-alone course, but is useful as a convenient reference library of relevant material for a course in TQM. BEST TQM is a rich learning environment which is designed to facilitate synchronous and asynchronous learning experiences for students at the university level and beyond. The primary focus of the package is on asynchronous, self-paced learning experiences. It appears that the package could serve the needs of on-campus students, place-bound students and industrial employees in an efficient manner. BEST TQM has been created as a cooperative effort between the Design Engineering Center and the ISDC.

6.1.1 Video

An example of the integrated use of video is shown in Figure 6. Xerox is a winner of the Malcolm Baldrige National Quality Award, and is one of the examples included in BEST TQM to demonstrate fundamental principles and implementation styles. Videos of these distinguished speakers are included directly in the various lessons and can be located conveniently from the course outline in the left panel display. The student simply clicks the play button, and the video starts. The speaker's comments are outlined to the left, and particularly important portions can be replayed at the student's discretion. Currently there are 33 video clips totaling 160 minutes of viewing included in BEST TQM. Additional video material is being added continuously, and the entire content of the package is reviewed and updated each semester.

6.1.2 Simulations

BEST TQM is designed to support student curiosity and experimentation. One of the simulations will be discussed herein in order to give a flavor of the capability. Student teams are asked to drop a yardstick and catch it at an assigned point, say 10 inches. The assigned target value is an important feature of the experiment. The ruler drop experiment[10] is a convenient way to generate data displaying variation, and simulates a manufacturing environment. Figure 7 gives a static view of this experiment in BEST TQM. Instructions for completing the experiment are given, data is collected in a list, and a calculator is provided to allow students to perform simple statistical calculations. Two versions of the calculator are provided. The simple form of the calculator is useful if students are learning to perform simple statistical calculations, such as average, range, and standard deviation. An expanded version of the calculator with statistical

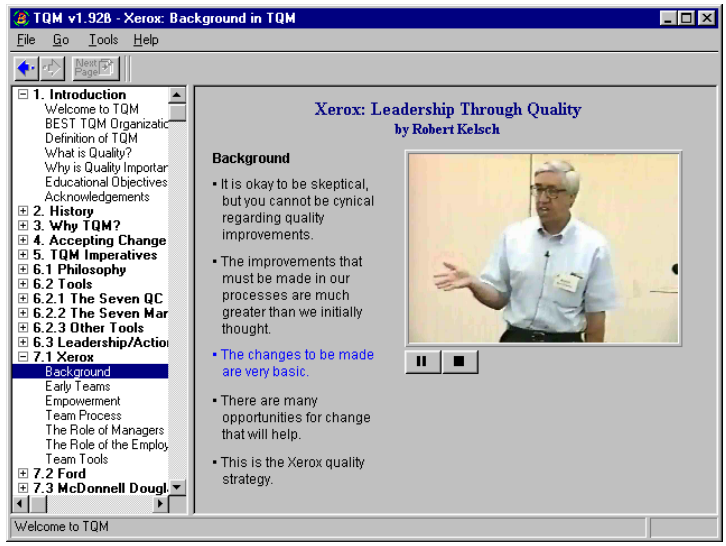

Figure 6: Video Integration in BEST TQM

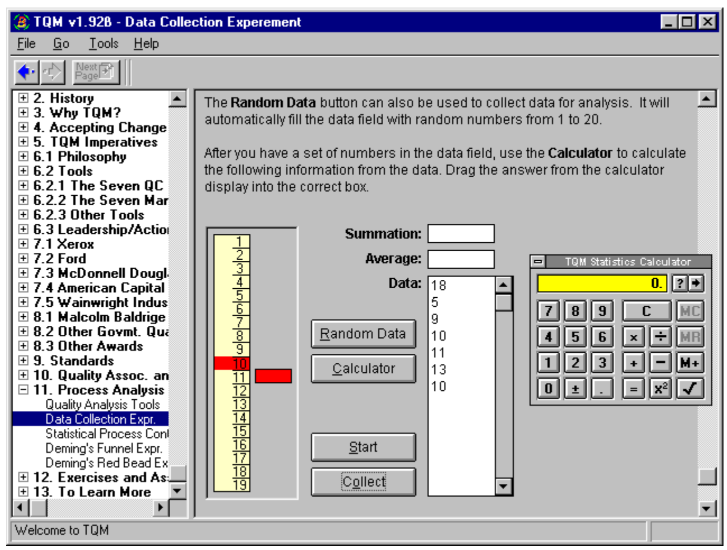

Figure 7: BEST TQM Data Collection Experiment

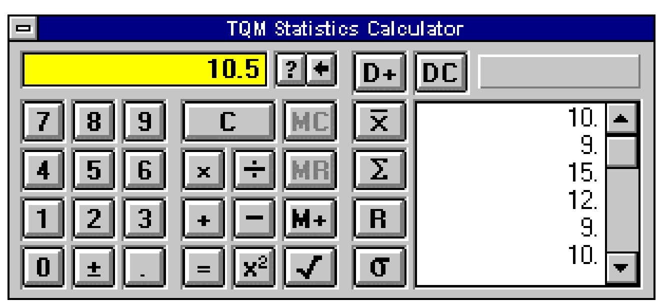

Figure 8: Statistics Calculator in BEST TQM

functions built-in is also provided as shown in Figure 8. This form of the calculator is very helpful to students when completing more advanced assignments in the laboratory.

7. Development Tools

A variety of software tools are being used by the authors to create the learning environments discussed in this paper. The sections which follow provide brief summaries on a few of the more important tools currently used in these development efforts.

7.1 ToolBook[11]

ToolBook is a multimedia authoring tool with a very powerful programming language called OpenScript, which is similar to Visual Basic. ToolBook files, called "books," can run on any Windows operating system version 3.1 or greater with a freely distributed runtime program. ToolBook files can also be viewed in a Windows-based web browser with a Neuron plug-in or active-X control.

ToolBook is the authoring system of choice for the ISDC at UMR because of its ease of use and incredible power. ToolBook has an easy-to-use visual interface for drawing buttons, fields, graphics objects, etc.; and a wide array of built-in features to help in the authoring process. The OpenScript language of ToolBook has numerous built-in functions to do almost anything needed in a Windows program, and it has the ability to link directly into the Windows API (Application Programming Interface) or DLLs (Dynamic Linked Libraries) written in any language, for the additional power of low level programming. These capabilities make ToolBook more of a programming platform than an authoring tool.

7.2 Dreamweaver[12]

Dreamweaver is an extremely powerful web authoring tool. Its visual development environment and robust "round-trip" HTML editing capability enable the developer to quickly create attractive, effective web pages; to work directly with the HTML code; and to cascade the resulting modifications back to the visually-developed web elements. It also provides an assortment of tools for optimizing the users' HTML code, verifying cross-browser compatibility, and for performing site management.

7.3 RealProducer / RealPlayer[13]

Streaming media in web-deployed courseware developed by the ISDC utilizes RealSystem compression and delivery. RealSystem was selected because of the combination of quality and small file size of the compressed media files, and also because of RealNetworks' Surestream capability. Surestream enables the web server to dynamically determine the bandwidth available to the user, and to deliver the streaming audio or video at the corresponding quality level. It also has the capability to change this quality level in mid-transmission, thereby minimizing interruptions to the streaming media.

7.4 Flash[14]

Flash is a vector-graphics program used to create dynamic web content. Through Flash it is possible to develop animated content in total synchronization with the corresponding audio. This is normally a problem due to page latency and fluctuations in available bandwidth. Flash movies utilize the Shockwave[15] plugin, which Macromedia claims is already installed in the browsers of 83% of the current web users. This plugin is freely available from the Macromedia web site, and is a standard feature in the Netscape 4.7 and Internet Explorer 5.0 basic installation.

8. Closure

Professor Davis and the ISDC are currently supporting professors in a number of departments as they attempt to create state-of-the-art, multimedia learning environments. The medium of delivery is moving from compact disk (CD) to the web. Professor Ragsdell is currently developing, with the aid of the co-authors of this paper, four multimedia courses, EMgt-374 (Engineering Design Optimization), EMgt-375 (discussed herein), EMgt-376 (Introduction to Quality Engineering) and EMgt-475 (discussed herein). The intent is to create attractive learning environments for content-intensive and useful courses, which will stimulate students to very high levels of achievement. These environments are also being designed to assess the students' preferred learning style and pace, and to configure the presentation of content accordingly.

Recent efforts have been primarily directed at the off-campus, place-bound, distance student. Surprisingly, these efforts to create CD and web-based materials are very popular with on-campus students. The on-campus students appreciate the focused organization that this mode of instruction requires, and the availability of materials at the students' convenience. The authors observe that students in problem oriented courses (statics and dynamics for instance) generally need drill and exercise (solution of many problems) in order to learn the basic concepts. On the other hand, when these students are allowed to navigate as they choose they will almost invariably avoid the automated problem solutions, and go directly to the tests needed to progress to the next module. It appears that many students are more interested in completion than in mastery of the fundamental concepts. The addition of simulations and demonstrations seems to mollify this malady to some extent. Automated testing and grade reporting (immediate feedback) is of great value to student and professor alike.

The non-problem oriented courses (total quality management and quality engineering) seem to benefit greatly from the use of imbedded videos, especially of outside experts in the field. On the other hand, students seem to quickly become bored with long videos of the instructor covering course material in a normal lecture format. Dynamic slide presentation using sequenced audio (RealAudio) and Flash seems to hold the students' attention and stimulate inquiry. The use of simulations and sharply focused videos appears to be popular, as well. Observations indicate that the Keller Plan is an ideal format for the distance student. The convenience of proceeding at the student's individual pace is compelling and increasingly necessary. Course modularization and forced mastery of concepts is of demonstrable value, and facilitates the needed asynchronous student progress. The pedagogy of the Keller Plan seems ideal, especially when implemented with modern technology.

Finally, it is the authors' experience that these efforts, in the end, result in increased faculty workload. Outside observers may comment that having the course "in the can" surely releases faculty for other activities, such as research or service. Experience indicates just the opposite. First and foremost, these course development projects are never complete. Content is always in need of improvement, and delivery technology is changing at such a high rate that delivery format becomes outdated almost as it is used. Ragsdell recalls his early years of video course development (1970's and 1980's at Purdue University and later at the University of Arizona), where 1 hour of professional quality video course material requires 30-40 hours of effort. Not surprisingly, the course formats discussed herein require more. Significant staff and student support are required. Do not underestimate the development and maintenance costs of courses using these formats. On the other hand, the satisfaction associated with increased student learning, achievement and satisfaction is extremely rewarding.

Comments and questions related to these efforts are welcome, and should be directed to any of the authors.

References

1. Keller, F.S. and J. Gilmour Sherman, The Keller Plan Handbook, Benjamin, 1974.
2. Acrobat Reader, Adobe Systems Incorporated, www.adobe.com.
3. Fowlkes, W. Y. and C. M. Creveling, Engineering Methods for Robust Product Design, Addison-Wesley, 1995.
4. WebCT Learning Environment; WebCT, Inc., www.webct.com.
5. Gabor, Andrea, The Man Who Discovered Quality, Random House, 1990.
6. Deming, W.E., The Elementary Principles of the Statistical Control of Quality: A Series of Lectures, Tokyo, Nippon Kagaku Gijutsu Remmei, 1951.
7. Deming, W.E., Quality, Productivity, and Competitive Position, MIT Press, 1982.
8. Deming, W.E., Out of the Crisis, MIT Press, 1986.
9. Latzko, W.L. and D.M. Saunders, Four Days with Dr. Deming, Addison Wesley, 1995.
10. Ragsdell, K.M., Homework Three: Yardstick Data Collection, Engineering Management 375: Total Quality Management, Fall, 1998.
11. ToolBook Instructor; Asymetrix Learning Systems, Inc., www.asymetrix.com.
12. Dreamweaver; Macromedia, Inc., www.macromedia.com.
13. RealProducer/RealPlayer; RealNetworks, www.realnetworks.com.
14. Flash; Macromedia, Inc., www.macromedia.com.
15. ShockWave; Macromedia, Inc., www.macromedia.com.

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